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QUANTIZATION OF RISKS INVOLVED IN SUPPLY OF READY MIX CONCRETE IN CONSTRUCTION INDUSTRY IN INDIAN SCENARIO

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ABSTRACT

In today's business environment, the coordination of just-in-time (JIT) production and transportation is one of the most challenging aspects to ensure timely delivery of materials to distributed customers. Several risk factors make JIT supply chains more vulnerable and methods for analysing and understanding supply chain risks are still needed in construction. This paper describes the implementation of failure mode, effects, and criticality analysis (FMECA) tool and discrete event simulation to assess supply chain risks, identify vulnerabilities, and measure the impact of disruptions of a ready-mix concrete supply chain. Interviews with concrete batch plant managers and current demand, production, and delivery performance data served as input for analysis. We provided a systematic method that can be used by concrete suppliers to improve planning and delivery of ready-mix concrete. Different mitigation strategies were suggested based on our findings.

Key words: JIT, Risk management, Project Success, Procurement, Procurement Frameworks, Procurement Systems, Construction Management.

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1. INTRODUCTION

Risk management is a process aimed to identify and assess risks in order to enable the risks to be clearly understood and managed effectively (Hillson 2002).This process is a critical part of project management of large engineering and construction projects in an attempt to reduce uncertainties and to achieve project success (Akintoye 2008). Unmanaged or unmitigated risks are one of the primary causes of project failure (Royer 2000).

Supply Chain Risk management is emerging as an important contributor to most fields of management decision and control. Managing supply chain risk is difficult because individual risks are often interconnected. As a result, actions that mitigate one risk can end up exacerbating another (Christopher 2004). For example, ajust-in-time supply chain, while low inventory levels decrease the impact of over forecasting demand, they simultaneously increase the impact of a supply chain disruption. Supply chain risks can become full-fledged supply chain problems, causing unanticipated changes in flow due to disruptions or delays. Supply chain disruptions are unintended, undesirable events that degrade both supply chain and project performance (Wagner and Bode, 2008). Thus, the goal of supply chain risk management is the design and implementation of a supply chain which anticipates and successfully copes with disruptions. Despite increasing awareness among practitioners, the concept of supply chain vulnerability and supply chain risk are still in their infancy (Blackhurst 2003). There is compelling research illustrating the importance of effectively managing supply chain disruptions as well as the lack of preparedness of most companies (Mitroff and Alpaslan 2003).Construction supply chains are not different. Construction managers need better methods for analyzing and understanding supply chain risks and vulnerabilities. This paper describes the implementation of failure mode, effects, and criticality analysis (FMECA) tool and the results of discrete event simulation to assess supply chain risks, identify vulnerabilities, and measures the impact of disruptions of a ready mixconcrete supply chain. This paper does not intend to present the detailed simulation experiment but present the benefits of using this tool with FMECA to provide useful information for the construction planning process.

RMC is the e-generation's next material for the Indian building industry which will help save money, time, and manpower and make available the quality control at our door step. The production of ready mixed concrete has been started in 1930's. Since then it has gained wide spread acceptance in many developed and developing countries. In developed countries like U.K. and U.S.A. etc. the ready mixed concrete forms a major sector of construction industry. Even the developing countries like Thailand and Malaysia, RMC is being used substantially. The RMC business in India is in its Infancy. For example, 70% of cement produced in a developed country like Japan is used by RMC business there, here in India RMC business uses around 2% of total cement production.

2. LITERATURE REVIEW

The National Ready Mix Association (March, 2011) indicate that ready-mixconcrete is a $ 30 billion industry in the USA, with an annual output of 351 million cubic meters, and nearly 75% consumption of cement is through the ready-mixconcrete route (National Ready Mix

Concrete Association: http//www.concnt.org).Several sources of risks can be identified in the production system for ready mixconcrete:

- Ready-Mix Concrete Plants have Limited Capacity: A plant's capacity is determined by either batching capacity or delivery capacity. Batching capacity is determined by the time needed to measure, dispense, and mix ingredients, then load them into a truck. Delivery capacity is determined by the number of trucks and drivers that service the ready-mix concrete plant. Typically, a ready-mix concrete plant may own 25 to 30 trucks and plant operators will try to keep them busy at all times.
- Demand Fluctuation: Demand for ready-mix concrete fluctuates throughout the day, week, and year. At the time a contractor calls in an order to a ready-mix concrete plant, many unknowns will be revealed. How the plant and the contractor handle these unknowns can be the determining factor for managing the risk of ready mix concrete delivery disruptions.
- Placement Size: Large placements require uninterrupted supply of concrete in order to avoid unplanned construction joints. To achieve the required continuity of delivery, plant and site must communicate in real time. A large job may tie up a considerable number of trucks and thus a plant's capacity.
- Delivery Cycle and Location: Since concrete should typically be placed no longer than ninety minutes after addition of water, travel from ready-mix concrete plant to a site should not take much more than half an hour or so. A plant's operating radius therefore tends to be limited based on the nature and condition of haul roads.
- Accuracy in Order Quantity: Accuracy in order quantity is important because contractors tend to order a little less than what they actually expect to need and count on being able to get an extra truck on short notice should one be needed in the process of finishing a placement.

3. METHODOLOGY

The methodology shall be collecting the technical details from the available literature on the subject and through discussion with the people in the field, market research: Preliminary survey of potential users of the product through informal discussions and questionnaires. Based on interaction with the companies executing concreting works using RMC and to study present status of use of RMC in construction industry in overall perspective and to examine trends and patterns of growth.

4. FMECA

In this study, the researchers have studied the immediate supply chain partners of a ready-mix concrete plant. The network model included two suppliers (S1-cement, S2-chemicals), the plant, the delivery channels (including trucks) and final customers (multiple job sites) that dictate the demand structure. This is a typical case of just in time supply chain. The process starts when a customer's order arrives at plant with the following attributes: customer name, company name, and contact phone number. Delivery address, date of delivery, either "will call" or "active order", total yardage of the day (if not known an estimate), number of loads and load sizes, concrete specifications, and payment method. In order to identify the major risks inherent to this supply chain, a series of interviews were conducted within the company (ready-mix plant). Ten people directly involved in the fabrication, delivery, and purchasing of critical materials participated in this research. Based on these interviews, a FMECA table was built. FMECA is a well-documented method used to quantify and analyse safety concerns for a product or a process. As an input, it takes plans, probabilities and frequencies based on historical knowledge. As an output, FMECA provides a list of most critical risks as well as some target mitigation actions. Each entity of the supply chain network that may be exposed to different risks is listed. For each of these entities, the failure modes have been defined.

This information was gathered from expert interviews and brainstorming sessions. Once the potential failures are identified, the potential effects have been listed. The effect of each probable fault on the overall system performance is examined in a systematic way and each failure mode is associated with a severity index (S). The severity index is used to classify the relative importance of the effects due to a failure mode. Engineering judgments and historical records stored in databases were used to determine the severity index. The research team then listed the potential causes of the failure modes and evaluated the likelihood/probability of their occurrences using information obtained from past statistical data sources about the process, monthly reports on traffic monitoring, and daily operator performance evaluation results. Occurrence rate is a numerical subjective estimate of the likelihood that the cause, if it occurs, will produce the failure mode and its particular effect. Finally, failure detection and possible correction actions have been determined to prevent the cause and occurrence for the potential fault scenarios. The ready-mix plant already performs some of the process control activities. They can be used to identify and detect the failures or to prevent the cause of the failure modes from occurring, while some of them represent the proposed control processes which can be put in place. The possible control and detection process is assessed to determine how well it is expected to detect or control the failure modes or the probability that the proposed process controls will detect a potential cause of failure or a process weakness. Higher rankings represents remoter likelihood that risk factor can be controlled. It is common practice to assign a number from a 1–10 scale for the severity (S), probability of occurrence (O), and detection difficulty (D). The higher the assigned number is the higher the importance of the failure mode is with respect to the related index. Even though a great amount of historical data and information is available, decision makers still need to make judgments to score these parameters. This process is somewhat subjective and relies on the interviewees' experience and their confidence on the information available during the interview process. Twelve common supply chain disruptions have been determined and classified into four main groups. A criticality analysis is further performed to enable a priority ranking among the identified risks. This ranking is done using the S, O and D values and referred to as the risk priority number (RPN).

$$RPN_i = Si * Oi * Di$$

For a given failure mode i, the higher the RPN_i, the more critical the failure is. Thus, RPN_i draws the system analyst's or supply chain manager's attention towards the most critical activities to eliminate or to reduce potential failure modes. The FMECA table provides practitioners with valuable information. First, the Risk Priority Numbers reveal the following most critical failure modes for each one of the entities studied. For example, poor quality of the purchased raw materials from supplier has the highest RPN (RPN = 120) for the supplier entity. Related to the Ready-Mix Concrete Plant entity, technical problems and breakdown of the machinery has the highest RPN (RPN = 168). Technical problems with delivery trucks (RPN=224) and human errors (RPN=128) are critical for the delivery channel entity. Finally, fluctuations in customer demand (RPN = 448) and loss of market share (RPN = 378) are the highest values for the customer entity. Second, analysing, the common potential effects of the failure modes was observed and expressed either in terms of delay or in terms of cost (or profit). Finally, provide practitioners valuable information on the possible actions to put in place. For instance, in the case of the failure mode due to the machine breakdowns, insufficient maintenance is shown as a potential cause and periodic maintenance is proposed as a mitigation action. A failure Mode Effects and Criticality Analysis (FMECA). The major potential failure modes that act as supply chain risk factors have been included in the discrete event simulation model (i.e. the quality problems arising from the purchased raw materials from suppliers, technical problems and breakdown of the machinery at the Ready-

Mix Concrete plant, technical problems with delivery trucks and fluctuations in customers demand). When any concrete order is being processed and delivered, if any failure is observed, the ready-mix plant can first try to solve the problem caused by this failure. This adds up additional time for analysis, but the company will save money and time in the long run.

Table 1 Received outcomes

Entity	Potential failure / error mode	Potential effect(s) of failures	Severity (s)
Suppliers	1-Poor quality in purchased raw materials from supplier 2-Raw materials scarcity 3-Losing the competitive advantage of supplier	1-Quality problems in productions of ready mix concrete, loss of customers 2-Delayed arrival of raw materials at the plant3-inefficient capacity utilization, Inflexibility in supply	5 8 7
Ready-Mix Concrete Plant	1-Lack of operator /Dispatcher 2-Tehnical problems/breakdown of the machinery or other technical elements 3-Human errors	1-Delay in delivery and scheduling problems 2-Damage to machinery or Delay in delivery, loss of profit 3-Accidents, damage to machinery, delay in delivery	8 8 3
Ready-Mix Concrete Delivery Trucks	1-Human errors 2-Technical problems with delivery trucks 3-Traffic and highway problems	1-Accidents, loss of profit, delay in delivery 2-Supply interruptions, loss of profit 3-Delay in delivery	8 8 6
Customers	1-Fluctuations in customer demands 2-Loss of market share 3-Customer's order problems (short in quantity)	1-Difficulties in orders of raw materials and planning 2-Low profit rate 3-Delivery for small quantities frequently	8 9 6

Table 2 Determination of risk priority number

Potential cause(s) of failures	Occurrence (O)	Detection/current controls	Detection score (D)	Risk priority number (RPN=S*O*D)
1-Low suppliers reliability 2-Orders planning and scheduling errors 3-Monopology, contractual agreements	3 1 1	1-Quality control, inspection 2- Forecasting, MRP, Communication and information sharing with suppliers 3-Alternative suppliers	8 3 4	120 24 28
1-Operator ,dispatcher or driver absence, strike 2-Insufficient maintenance, low technical reliability 3-Loss of motivation, lack of experience or training, working conditions	1 3 2	1-Motivation, good relations with Labour union 2-periodic maintenance Training, ergonomic analysis of working conditions, rewards system, social activities	7 7 4	56 168 24
1-Ineficient or missing CRM (customer relation management) 2-High competition in the marketplace 3- Behaviours of the competitors	7 6 3	1-Demand forecasting, flexible production system 2-inventory management and control 3-Marketing strategies	8 7 7	448 378 126

5. MAJOR ADVANTAGES OF RMC

A. Technical Advantages

Use of RMC leads to strict control of A/C and W/C ratio, accurately controlled proportions leading to overall better quality of concrete structures. Early commissioning of projects is possible due to speedy construction. Utilization of high performance concrete is another possibility resulting in improved durability of structures.

B. Environmental Advantages

Fleets of trucks carrying sand and aggregates inside city areas get replaced by transit mixers. Dust pollution, due to unloading of cement, aggregates etc. is eliminated. Fly ash and slag could be used converting the waste into high quality concrete.

C. Social Advantage

Standard of living of concreting gangs is improved by upgrading skills; accidents including skidding of vehicles over sand, stored on roadside, are avoided in turn eliminating lot of public nuisance. Clogging of drains due to sand and aggregate stored at site, spilling into drains is totally avoided.

D. Commercial Aspects

In a typical site mixed concrete wastage of raw materials, wastage of concrete during placing, high supervision cost due checks required at site on raw materials are unavoidable issues. RMC eliminates these factors. Investment in material testing equipment on site- to –site basis is no more required with use of RMC. High overheads of longer project duration have serious commercial implication and by use of RMC speed of work is increased substantially thereby reducing overall project duration.

E. In recent earthquake in Gujarat, the damage to the structures and human life was tremendous. One of the most apparent observations was that poor bond between concrete and steel and inferior quality of concrete were the accelerating factors towards this damage. By use of RMC, w/c ratio can be strictly controlled and also proper grading of aggregates can be achieved. These two factors alone can help increase the bond of concrete with reinforcing steel and thus increase in resistance of the structures against such natural calamities. It is unimaginable how many lives can be saved by this simple step as engineers and architects by changing over from traditional methods to this forward approach to quality and durable construction. Adoption of RMC is not a substitute to correct engineering design of structures. In cities the pollution levels have increased substantially and are on increase every day. Calcium hydroxide from concrete reacts with these pollutants leading to deterioration of concrete and hence early failure of structures. However by controlling water cement ratio of concrete properly, the required impermeability can be achieved to stop the interaction of these pollutants with concrete inside the structure. Further use of fly ash etc. can create very low permeability levels. This is possible by use of RMC. These are two critical issues for urban construction in India and to solve these RMC is a non-negotiable option.

F. Conservation of Natural Resources

Limestone is the raw material for the manufacture cement and limestone is a limited resource." It cannot last forever". We need to realize the importance of this fact. We need to use our cement rationally. Whereas we talk about huge figures describing development and building needs of our country, Concrete still remains the most widely used and environmentally friendly construction material to achieve this. Whatever we build should be aimed at improving the quality of life for a long period with focus on durability. With these aspects in mind cement needs to be used judiciously, use flash, slag etc. and best mechanism in this action process seems to be "adoption of RMC" thus relieving pressure on natural resources. Let our future generations not blame us for not conversing our natural resources.

5.1. Logistics Advantage of RMC

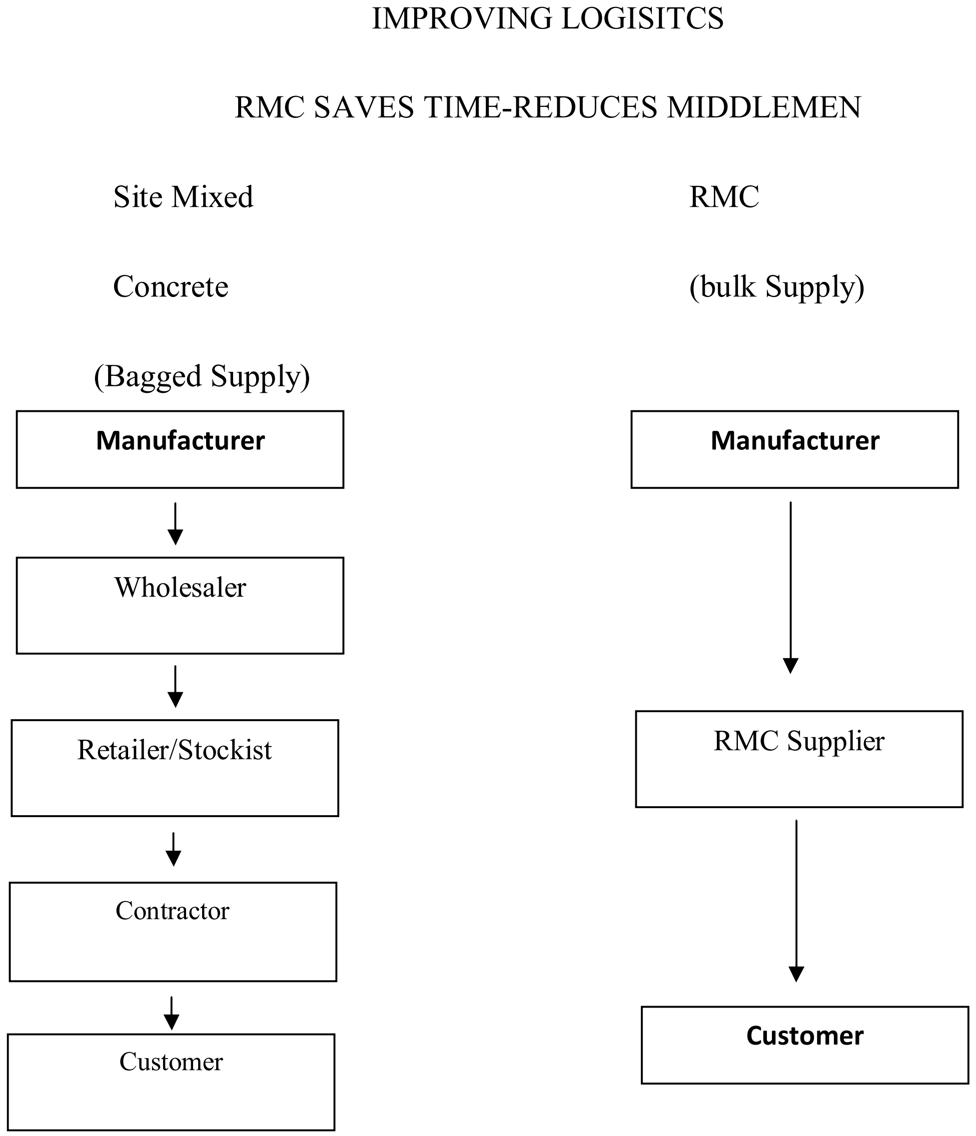

Figure 1 Flowchart showing RMC benefits

6. CONCLUSION

The future of RMC in India is very bright. Expect that within ten to fifteen years, number of ready mix concrete plants will come up in different parts of the country and nearly ten to fifteen percent of cement consumption will be through ready mix concrete. The government and local bodies should encourage the use of ready mix concrete by suitably amending the tender clauses and to provide facilities to the entrepreneurs to set up RMC plants.

The allotment of land on concessional rates and availability of water, electricity and other Infrastructure, and removal of sales tax by State Government would accelerate the growth of RMC industry in India. The study reveals that it is economically viable to set up a ready mix concrete plant provided there is a good demand in the surrounding area and plant capacity up to seventy percent is utilized. At present, there are limited numbers of such potential areas.

However, with the economic liberalization and emphasis on development of infrastructure and housing in the country as announced in the recent budget, more and more potential areas for use of ready mixed concrete would emerge leading to the growth of RMC industry. The action to be taken in the event of non-compliance should be determined by the purchaser. This may range from qualified acceptance in less severe cases to rejection and replacement in the most severe cases. In determining the action to be taken, due regard should be given to the degree of non-compliance and its technical consequences, and to the possible remedial actions available. For example, it may be possible to re-design the structure to allow for the lower strength concrete to be acceptable for structural purposes.

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